METHOD AND APPARATUS FOR SCANNING FEET FOR THE PURPOSE OF MANUFACTURING ORTHOTICS AND OTHER FOOTWEAR

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BACKGROUND OF THE INVENTION

Field of the Invention

This invention relates generally to a method and apparatus for obtaining foot images for use in making orthopedic appliances. More particularly, the present invention is connected with the use of a flat-bed scanner for obtaining foot measurements for the making of arch supports, orthotics, custom shoes, and custom sandals.

Background Art

In the making of orthopedic appliances such as custom orthotics, custom shoes and custom sandals, all referred to herein as "corrective orthotics," to aid in the correction or prevention of malformations of the feet, it is necessary to first obtain an image of the foot. Measurements are then taken of the image for the purpose of duplicating the contours of the foot. For accuracy, the foot image must be taken while the foot is positioned in a normal weight bearing condition. The conventional practice, which has remained unchanged for years, is to make a depression with the foot. Plaster of Paris is then poured into the negative depression, producing a duplicate mold or cast of the bottom of the foot. From the molded form, which provides an exact duplication of the contours of the foot, an orthopedic device such as an arch support or an entire shoe is made. One material used for making the negative image is a foam that is in a box. The patient steps into the foam to make an impression of the foot.

The present methods of producing an image of a foot require a significant amount of material and equipment in terms of volume and mass. Additionally, the casts produced are voluminous, requiring significant storage space. Transfer of the casts to another location requires significant effort and expense as well.

There is, therefore, a need for a method and device for acquiring measurements and

data necessary for producing orthotics and corrective shoes and sandals using electronic data that can easily be stored and transferred over common communication pathways.

Summary of the Invention

It is an object of this invention to provide a novel method and apparatus for obtaining foot measurements for the making of corrective footwear such as arch supports, orthotics, and corrective shoes and sandals. It is a further purpose of the present invention to produce data needed for the necessary measurements in electronic format for ease of storage and transmittal.

Modern electronic technology has made it possible to utilize a flatbed scanner to record a color image of a patient's foot, from which the necessary measurements and other observations may be obtained. The measurements may be used to produce corrective orthotics, shoes, or sandals. The corrective support in any of these products does not mirror the contours of the foot, but rather restores normal foot balance.

Another object of this invention is to improve on known methods of making arch supports, by providing a method and apparatus by which accurate measurements, visual observations, and color variations of an electronic image (or a hardcopy of an electronic image) serve as a basis for a corrective arch support. This approach eliminates a step that can be rather messy and is a sometimes harmful process involving plaster of Paris.

Yet another object of this invention is to provide an improved method of using foot images to make corrective arch supports, which method includes the use of scans which lend themselves to an instantaneous image.

It is another object of this invention to provide a novel method of obtaining foot measurements as described herein before which may be performed easily and with a minimum of time and equipment, and which is effective and accurate.

The novel features which are believed to be characteristic of this invention, both as to its organization and method operation together with further objectives and advantages thereto, will be better understood from the following description considered in connection with accompanying drawings in which a presently preferred embodiment of the invention is illustrated by way of example. It is to be expressly understood however, that the drawings are for the purpose of illustration and description only and not intended as a

definition of the limits of the invention.

Brief Description of the Drawings

Fig. 1 shows a computer and a flatbed scanner.

Figs. 2 show two flatbed scanners in use scanning feet.

Figs. 3 show flow diagrams of foot scanning for single and dual scanner systems.

Fig. 4 depicts color scans of two feet.

Fig. 5 shows a line drawing of a foot.

Fig. 6 shows an orthotic.

Fig. 7 depicts a color scan of a foot and a ruler for making measurements.

Best Mode for Carrying Out the Invention

A flatbed scanner **100**, depicted in **Fig. 1** is used in the present invention to obtain electronic color images of a patient's feet. The scanner is connected, electronically, to a personal computer **110**. Image processing software (see Appendix) within the computer **110** organizes the data to present them most conveniently to an operator.

In **Figs. 2**, representative configurations for flatbed scanners **100** are shown with a patient standing thereon. In **Fig. 2a**, a single-scanner unit is shown. Only the right foot **200**, in this instance, is on the scanner **100** and being scanned. The left foot **210** is on a surface that is at the same elevation as the flatbed scanner **100** so the patient may stand normally. The left foot **210** will be scanned after the patient is repositioned with the left foot **210** on the flatbed scanner **100**. In **Fig. 2b**, both feet **200, 210** are on scanners **100**. The feet **200, 210** may be scanned simultaneously or sequentially. The present invention is not limited to the physical configurations of the scanners **100** shown in **Figs. 2**.

Flow diagrams for the scanning process are depicted in **Figs. 3**. Focusing on **Fig. 3a**, the flatbed scanner(s) **100** is shown on the left while a personal computer **110** is shown on the right. Scanning control communication information **300** is passed between the personal computer **110** and the scanner(s) **100**. This passing of control information is the same as passed between any computer **110** and scanner **100** used for any purpose and includes commands from the computer **110** to begin or abort a scan, and signals from the

scanner **100** indicating it has finished a scan and is ready to perform another.

Fig. 3a represents either a single scanner operation or a dual scanner operation. In either case, the patient's feet are scanned one at a time. In **Fig. 3a**, the right foot **200** is shown being scanned first, but this invention is not limited to any particular order. After each foot is scanned, the data are transmitted to the computer **110** where software included on a CD with this application (see the Appendix for a directory listing) organizes them for ease of viewing and for the purpose of retrieving the measurements required to construct corrective footwear.

In **Fig. 3b**, a single or dual scanner system is depicted wherein both feet are scanned simultaneously and the data transferred to the computer **110** where the data are sorted for presentation and measurement.

Fig. 4 represents a pair of color images of feet as taken with a scanner. These images are captured by the scanner(s) and, through software, are displayed side by side on the screen as seen in **Fig. 4**.

In **Fig. 4**, the right foot **200** is on the right side and left foot **210** is on the left. The images are actually inverted so they appear on the predetermined side without being mirrored (or backwards). Size, dimensions, color variations, texture variations, and abnormalities are clearly visible in a typical image taken by a scanner. Depth perception is achieved by variations in colors and shading. Images closest to surface show as light tones **400** while areas further away darken **410**. Much more detail may be discerned in an actual scan than is depicted in **Fig. 4**.

The method of obtaining measurements for making a pair of arch supports is as follows. Place a foot **200**, **210** on the scanner **100**, the foot being positioned such that the entire foot will appear in the scanned image. The patient shall stand so that his or her weight is divided normally between both feet. If a single scanner **100** is employed (see **Fig. 2a**), the first foot is moved out of the window upon the completion of the first scan and the second foot is then placed on the scanner surface as the image is captured. If a dual scanner **100** is used (see **Fig. 2b**), it is not necessary to move the feet. These measurements and observations are then corrected for the building of corrective arch supports and like orthopedic devices, orthotics, shoes and sandals.

In **Fig. 5**, an outline primarily of the lowest surface of the right foot **200** is depicted.

This image will be used to describe specific dimensions and measurements used in designing corrective footwear. While the following measurements and observations are made of the right foot **200**, it is understood that the same measurements and observations will be made for the left foot **210**.

1. The length, *L* **500**, of the foot from the heel to the longest toe is measured. Such a measurement, and following measurements, may be by ruler (see **Fig. 7**), computer aided scale, or other instruments of accurate measurement.
2. The length, *LB* **505**, of the foot from the heel thereof to the ball of the foot is measured.
3. The width of the foot from the first metatarsal joint **510** to the fifth metatarsal joint **515** is measured.
4. The position of the metatarsal heads **520** is observed by visual means.
5. The position of the inner longitudinal arch (navicular) **525** is observed.
6. The position of the outer longitudinal arch (cuboid) **530** is observed.
7. Whether or not any of the metatarsal heads indicated generally at **520**, are "dropped" is noted. This can be determined by visual observation of coloration of feet and stress points at met heads.
8. Whether or not planter calluses exist on the bottom of the foot can be ascertained by visual observations.
9. Plantar abnormalities and their positions, if any, are ascertained by visual observations such as neuromas, bunions, warts, missing toes, calluses, ingrown toenails, hammertoes, corns and others. Can see muscle tone which aids in showing weakness in arches. Weight distribution is shown by coloration and pressure points, which aids in determining degree of correction of arches.
10. The presence of hallux valgus (bunion) is noted by visual observations and the degree of forefoot eversion.
11. Whether or not a "Taylor's" bunion is present is noted by observation. This bunion is found off the little toe area **535**.
12. Visual type observations are made of the inside of the arch **525** to indicate the presence and degree of pronation and the degree of forefoot eversion.
13. The presence and degree of suppination, always found at the outer side of the arch

as indicated generally at **540**, is observed along with degree of forefoot inversion.

14. The position of the toes is visually observed.
15. The entire images are analyzed to note any other type of plantar defects.
16. The position of the calcaneous is observed to check for pronation and supination around the posterior section **545**.
17. Visual inspection for Morton's toe to Morton's neuroma. Morton's toe being seen as a shortened great toe **550** and a longer second toe **555**. Morton's neuroma is seen between third **560** and fourth **565** toes as a color variation and indentation.

After careful analysis of the resulting measurements, visual observations, and color comparisons, the resulting data plus corrective measures are utilized in the laying out of the dimensions and sizes of materials for building corrective footwear such as a corrective arch support, orthotic, corrective shoe or sandal for the right foot **200**. An example of an end result is shown as an orthotic **600** in **Fig. 6**. It should not be overlooked, however, that the measurements, such as shown in **Fig. 7**, and observations made and taken from the electronic image of the right foot **200** were corrected prior to the formation of the arch support so as to provide an arch support to restore normal foot balance to the right foot **200**.

Incorporation-by-reference is hereby made to the computer CD submitted with this application. A directory listing for the CD is included in the appendix. The files included on the CD are briefly described in the appendix.

The above embodiment is the preferred embodiment, but this invention is not limited thereto. It is, therefore, obvious that many modifications and variations of the present invention are possible in light of the above teachings. It is, therefore, to be understood that within the scope of the appended claims, the invention may be practiced otherwise than as specifically described.